CHAPTER 6

OTHER CONSTRUCTION SITE VIBRATION PROBLEMS

6-1. General. The effects of particle velocity and airblast on buildings and people are not the only effects of construction blasting that need to be considered. Occasionally, blasting will cause unwanted settlement or pore pressure buildup in loose and medium density sands. Pile driving causes both noise and vibration which can have irrating effects off site. Dynamic compaction, the dropping of large weights on loose sandy soils to densify them, can produce unwanted off site vibration. Source material for addressing these questions can be found in Items 45-55. Figure 18 from Item 45 gives peak particle velocity versus distance relationships for various construction operations, all of which produce less vibration at a given distance than the detonation of 1 lb of explosive. Structural damage of buildings for these sources of vibration is of no concern beyond 100 ft.

6-2. Blasting Induced Pore Pressures and Settlements. Buried explosive charges are used to deliberately densify loose, wet sandy soils at construction sites (Item 55). It is possible to cause pore pressures to increase beyond the intended densification area as a result of the buried explosions, and for settlements to take place there as the pore pressures dissipate. Item 4 presents data from other sources indicating measurable settlement out to distance of about 60 ft from an 11 lb blast in loose wet sand. Item 54 indicated noticeable excess pore pressures from buried explosions in wet sands at a scaled distance of 25 $ft/lb^{1/3}$, and liquifaction (pore pressure ratio = 1.0) out to 6 to 17 $ft/lb^{1/3}$. Use of a scaled safe distance of 25 $ft/lb^{1/3}$, based on the weight of explosive in a single charge at the edge of the area being densified, should avoid unwanted settlements or pore pressures.

6-3. Dynamic Compaction. Dropping large weights on the ground surface is another means used to densify loose sandy soils (Items 50, 53, and 55). Item 55 gives a relation between energy (weight × distance dropped), radius and maximum particle velocity for dynamic compaction of wet sands. This relation is given in Figure 19. It is substantially more conservative than measurements reported in Item 50. That reference recommends that safe working distances from structures be determined from the following:

$$\frac{\sqrt{\text{Height of drop} \times \text{weight}}}{\text{Radius}} \leq 20 \ \frac{lb^{1/2}}{ft^{1/2}}$$

This criteria corresponds to the 5 in./sec level in Figure 19 and indicates, as do the data points in the figure, that the curve for dynamic compaction of wet sand given in Figure 19 is conservative.

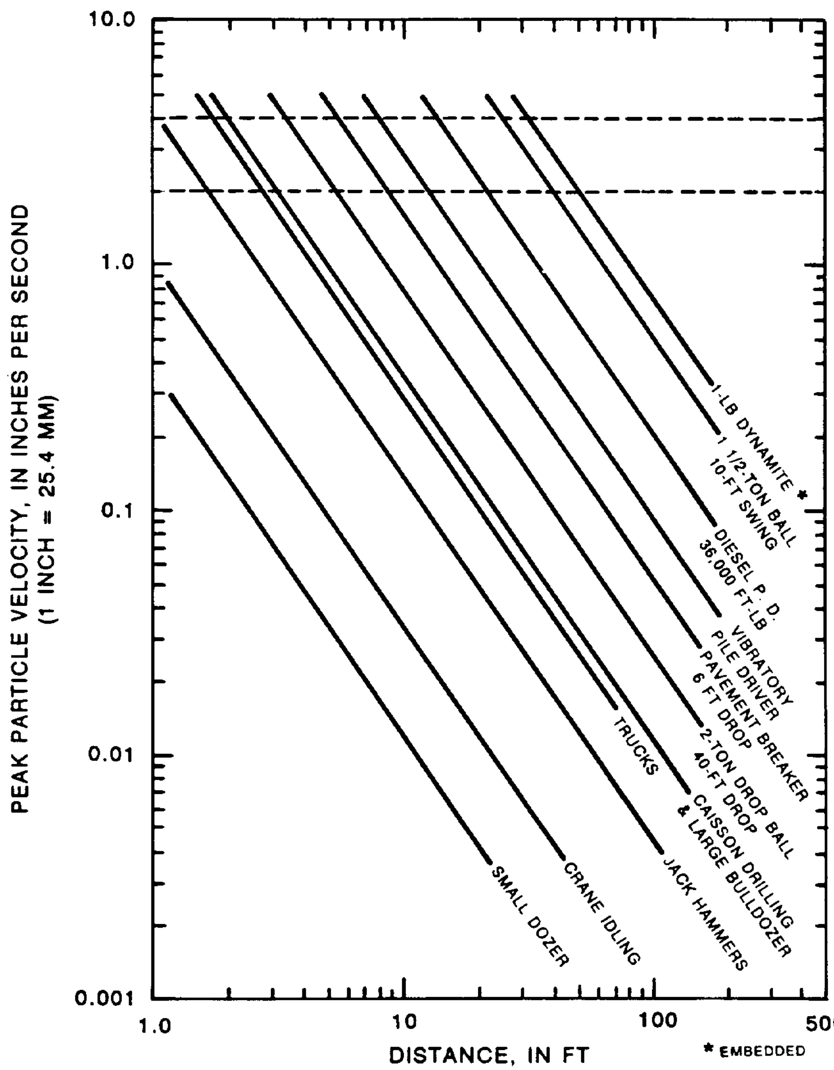

Figure 18. Maxium particle velocity versus distance for various sources of construction vibration (Item 45)

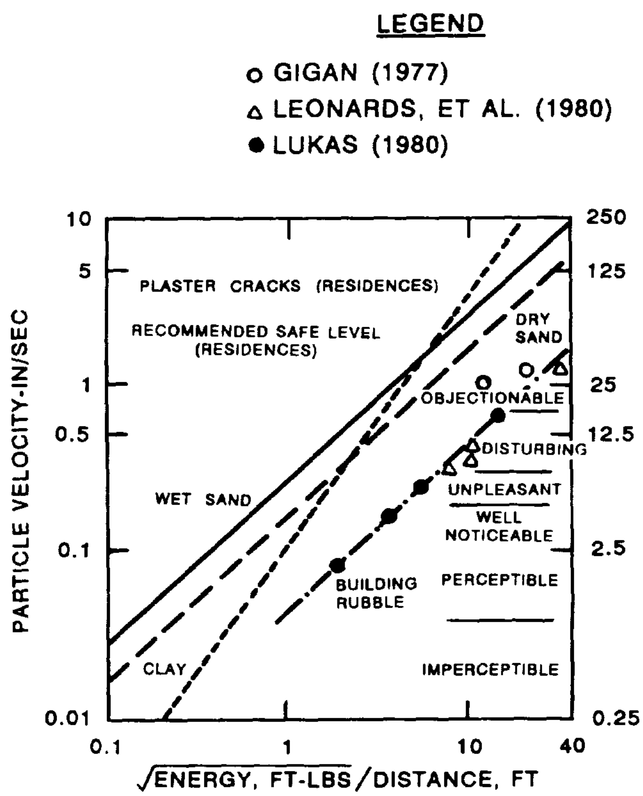

Figure 19. Particle velocity versus scaled distance for dynamic compaction (Item 55)

6-4. Pile Driving. In many urban areas, local ordinances prohibit pile driving in the night hours because of the sustained noise associated with the operation. Items 46 and 47 present ground motion data from sheet pile and friction pile driving, respectively. In the case of sheet pile driving both permanent settlements of the heterogeneous fill through which the piles were driven and surface ground motions were measured as a function of distance. The predominant frequency in the data was the frequency of the vibratory sheet pile driver, and the ground vibrations were roughly sinusoidal and steady state. The following tabulation gives an indication of the way effects decay with distance.

Table 10

Attenuation of Ground Motion from Vibratory Pile Driving

Distance ft	Maximum Acceleration, g	Maximum Particle Velocity, in./sec	Maximum Settlement, in.
10	0.30	0.50-1.50	0.5-2.0
20	0.16	0.20-0.50	0.0-0.6
40	0.06	0.15-0.30	0.0-0.1
80	0.02	0.05-0.10	0.0

Effects more than 80 ft from the work were found to be negligible. This is consistent with Figure 18.

In Item 47, ground motion measurements were made for various piles driven into sands. Results were as follows:

Table 11

Attenuation of Ground Motion from Impact Pile Driving

Pile	Hammer	Distance ft	Maximum Velocity, in./sec
HP 14 × 73	Vulcan 010	15	≦ 0.70
		21	≦ 0.58
		50	≦ 0.21
HP 14 × 73	Foster 4000	15	< 0.55
		20	≦ 0.51
HP 14 × 73	MKT DE 70B	15	≦ 0.50
		20	≦ 0.50
		29	≦ 0.61

As one would expect, the data above indicates that the vibrations are more severe than those from vibratory sheet pile driving. Beyond 25 ft, particle velocities will be less than 0.5 in./sec and the diesel pile driver line in Figure 18 conservatively envelopes all of the above data. Item 49 presents the following formula for estimating pile driving induced, maximum particle velocities.

$$U_R = .015\sqrt{\frac{W_o}{R}} \tag{23}$$

where

W_o = the hammer's rated energy per blow, ft-lb

R = radial distance, ft

U_R = maximum particle velocity, in./sec

This formula is less conservative than the line for the deisel pile hammer in Figure 18, and is in fair agreement with the data from Item 40 tabulated above.

6-5. <u>Damage Criteria for Pile Driving</u>. Steady state vibrations from pile driving activities are more likely to cause structural cracking or cosmetic damage at a given particle velocity level than are the intermittant, transient motions associated with blasting or dynamic compaction. It is recommended that particle velocities above 0.25 in./sec be avoided at nearby residential structures during pile driving as higher amplitudes will be uncomfortable for occupants.